

PHOTO STABLE ORGANIC SUNSCREEN COMPOUNDS WITH
ANTIOXIDANT PROPERTIES AND COMPOSITIONS OBTAINED THEREFROM

BACKGROUND OF THE INVENTION

5 Topical sunscreen compositions are commonly used during outdoor work or leisure as
a means for providing protection of exposed skin against acute and chronic adverse effects of
solar radiation such as sunburn, cancer and photo-aging. Many effective sunscreen
preparations are sold commercially or are described in cosmetic or pharmaceutical literature.
In general sunscreen preparations are formulated as creams, lotions or oils containing as the
10 active agent an ultra violet radiation absorbing chemical compound. The sunscreen functions
by blocking passage of ultra violet radiation thereby preventing its penetration into the skin.

 According to Zecchino et al. (US 5,008,100), sunscreen agents may be characterized
in the order of decreasing effectiveness as either highly chromophoric (monomeric organic
compounds and inorganic compounds such as titanium dioxide) and minimally chromophoric
15 (polymeric organic solids).

 Organic sunscreens are classified into UV-A filters, UV-B filters or broad spectrum
filters (UV-A and UV-B functionality in a single molecule) depending on the type of
radiation they absorb. UV-A sunscreens absorb radiation in the 320 to 400 nm regions of the
ultra violet spectrum and UV-B sunscreens absorb radiation in the 290 to 320 nm regions of
20 the ultra violet spectrum.

 Broad band sunscreens (UV-A and UV-B functionality) absorb radiation in the 290 to
400 nm region of the ultra violet spectrum and have two maximums, one in the UV-B region
and the other in the UV-A region.

 Representative references related to UV sunscreens are:

25 US Patent No. 3,278,448, which discloses cinnamic acid derivatives such as 4-
hydroxy, 3-5-ditertbutyl-alpha-carbomethoxy-cinnamic acid ether ester in column 2, line 20;

 US Patent No. 3,538,226, which describes cinnamic acid alkyl ester derivatives at
column 1, lines 15-31 and column 2, lines 1-12 and column 3, lines 30-55 and 60;

 US Patent No. 5,175,340, which describes cinnamic acid alkyl esters having hydroxy
30 radicals and alkoxy radicals on the phenyl ring, and

US Patent No. 5,830,441, which describes UV absorbents containing a cyano or cinnamyl moiety by the generic formula at col. 2, lines 1-21.

Other references which disclose cinnamide compounds include U.S. Patent Nos. 5,601,811, 4,335,054, 5,124,354, 5,294,643 and 5,514,711.

5 Unfortunately, some of the highly chromophoric monomeric organic compounds employed in sunscreen compositions are not photostable and the protection from sun damage is lost. In addition to lack of photostability of many organic sunscreens, they do not possess an antioxidant property which is essential for protecting skin or hair.

10 The ideal sunscreen formulation should be nontoxic and non-irritating to the skin tissue and be capable of convenient application in a uniform continuous film. The product should be chemically and physically stable so as to provide an acceptable shelf life upon storage. It is particularly desirable that the preparation should retain its protective effect over a prolonged period after application. Thus, the active agent when present on the skin must be resistant to chemical and/or photo degradation.

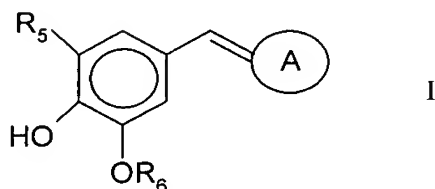
15 Techniques for stabilizing UV absorbent compositions are known. Representative disclosures in this area include U.S. Patent Nos. 5,567,418, 5,538,716, 5,951,968 and 5,670,140.

20 It is desirable to provide the antioxidant and photostable sunscreen functionality in a single molecule to enhance the effectiveness of the antioxidant properties.

SUMMARY OF THE INVENTION

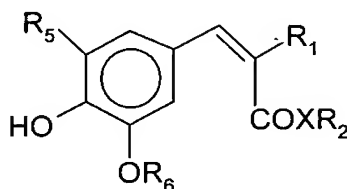
There is provided by the present invention compounds with sunscreen activity, i.e. they are chromophoric within the ultra violet radiation range of from 290-400 nm and they

also exhibit antioxidant properties. These compounds are represented by general formula I



In formula I, A is a moiety which provides chromophoric properties within the UV radiation range of 290-400 nm. This moiety comprises one divalent group or two monovalent groups with at least one group having carbonyl (C=O) functionality. For formula I, each R6 is independently linear or branched C1-C8 alkyl and R5 is hydrogen or R6. The one or more compounds of formula I can preferably stabilize an additional sunscreensing agent against photodegradation from exposure to sunlight. Preferred compounds are of formula II below.

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For formula II,

R1 is selected from the group consisting of -C(O)CH3, -CO2R3, -C(O)NH2, -C(O)N(R4)2, and -CN;

X is O or NH;

R2 is linear or branched C1 to C30 alkyl;

R3 is linear or branched C1 to C20 alkyl;

each R4 is independently hydrogen or linear or branched C1 to C8 alkyl;

R5 is linear or branched C1-C8 alkyl or hydrogen; and

R6 is linear or branched C1-C8 alkyl.

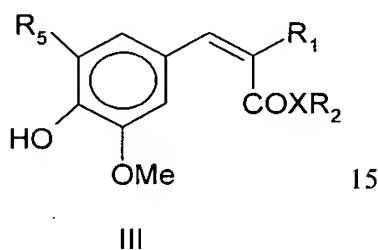
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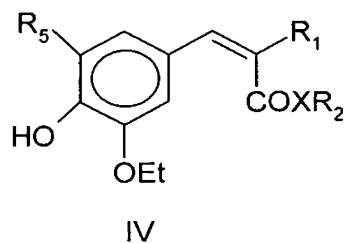
Included within the preferred compounds are those of formula II wherein R₁ is linear or branched C₁-C₄ alkyl, X is oxygen and R₂ is linear or branched C₁-C₁₂ alkyl. Of these compounds, those more preferred have R₁ as C(O)CH₃ or CO₂R₃ wherein R₃ is a linear or branched C₁ to C₄ alkyl. For compounds wherein R₁ is C(O)N(R₄)₂, R₄ is preferably hydrogen or a linear or branched C₁-C₄ alkyl.

While compounds having from C₁-C₄ alkyl groups for R₂ and R₃ are preferred, significant utility can be obtained from compounds wherein R₂ and R₃ are linear or branched C₈ to C₂₀ alkyl or C₁₂ to C₂₀ alkyl groups.

Another preferred class of compounds are those of formulae III and IV wherein R₁ and R₂ are as defined for formula I with R₃ being C₁-C₈ alkyl and R₄ being C₁-C₄ alkyl.



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Examples of compounds consistent with Formulae III or IV include those selected from the group consisting of

- ethyl- alpha- cyano-3-methoxy- 4-hydroxy cinnamate,
- ethyl- alpha- acetyl-3-methoxy- 4-hydroxy cinnamate,
- iso-propyl-alpha-acetyl-3-methoxy-4-hydroxy cinnamate,
- iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy cinnamate,
- 2-ethylhexyl-alpha-acetyl-3-methoxy-4-hydroxy cinnamate,
- diethyl-3-methoxy- 4-hydroxy benzylidene malonate,
- di-(2-ethylhexyl)-3-methoxy- 4-hydroxy benzylidene malonate,
- diisoamyl-3-methoxy-4-hydroxy benzylidene malonate,
- didodecyl-3-methoxy-4-hydroxy benzylidene malonate,
- dipalmitoyl-3-methoxy-4-hydroxy benzylidene malonate, and
- di-isopropyl-3-methoxy-4-hydroxy benzylidene malonate.

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di-(2-ethyhexyl)-3-methoxy-4-hydroxy-5-isopropyl-benzylidene malonate
di-isoamyl-3-methoxy-4-hydroxy-5-tert.butyl-benzylidene malonate
iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy-5-isopropyl cinnamate
5 iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy-5-tert.butyl cinnamate

The present invention also provides sunscreen formulations which comprise a compound of formula I, II, III and/or IV. These sunscreen formulations are effective in absorbing illumination in the range of wavelengths of 320 nm and above. Amounts of the compounds of formula I, II, III and/or IV within such compositions typically range from 0.1 to 40 wt% based on the total weight of the sunscreen. These sunscreen formulations can contain one or more additional organic sunscreen agents for filtering UV-B or UV-A rays or they may additionally contain one or more metal oxide sunscreen agents such as titanium dioxide or zinc oxide.

These sunscreen formulations may additionally contain a carrier and at least one component selected from the group consisting of dispersing agents, preservatives, anti-foams, perfumes, oils, waxes, propellants, dyes, pigment emulsifiers, surfactants, thickeners, humectants, exfoliants and emollients. These sunscreen formulations may be in the form of a cosmetic composition with a cosmetically acceptable carrier and one or more cosmetic adjuvants. The sunscreen formulation can optionally have conventional antioxidants or other stabilizers which do not have UV absorbing characteristics.

Methods of using these sunscreen compositions and methods for improving the photostability of sunscreen formulations are also provided. The methods of using the sunscreen formulations comprise applying a sunscreen formulation which contains a compound of formula I, II, III and/or IV to a substrate. Preferred substrates are skin and hair. To improve the photostability of a sunscreen formulation, a compound of formula I, II, III and/or IV is added to the sunscreen formulation in an amount sufficient to reduce the loss of UV absorbance of the sunscreen as it is irradiated. Typical amounts fall within the range of 0.1% to 40 wt%, based on the total weight of said sunscreen formulation. More typically, the amount falls within the range of 1 wt% to 25 wt%. The amount of organic sunscreen compound of formulae I, II, III and/or IV, preferably ranges from about 3 wt% to about 15

wt% of the sunscreen formulation. Other ingredients referred to above and discussed more particularly below are generally used in an amount from about 0.1 wt% to about 10 wt% of the sunscreen formulation. The balance comprises a cosmetically or pharmaceutically acceptable carrier.

5 The sunscreen formulations of this invention preferably offer protection from UV radiation with wavelengths of about 290 nm to 400 nm and preferably from wavelengths in the range of about 290-370 nm. Sunscreen formulations of this invention also typically have a sunscreensing protection factor (SPF) range of from about 2 to 60, with a preferred SPF range of from about 10 to about 45. The target SPF range can be achieved with a
10 combination of both inorganic and organic chromophoric compounds. SPF is determined by techniques well known in the art, on human skin as described in the Federal Register, August 25, 1978, Vol. 43, No. 166, pages 38259-38269 (Sunscreen Drug Products for Over-The-Counter Human Use, Food and Drug Administration). SPF values can also be approximated using in-vitro models as described, for example, in J. Soc. Cosmet. Chem. 44:127-133
15 (May/June 1989).

 The sunscreen formulations may contain dispersing agents, emulsifiers or thickening agents to assist in applying a uniform layer of the active compounds. Suitable dispersing agents for the sunscreen formulations include those useful for dispersing organic or inorganic sunscreen agents in either a water phase, oil phase, or part of an emulsion, including, for
20 example, chitosan.

 Emulsifiers may be used in the sunscreen formulations to disperse one or more of the compounds of formulae I, II, III and/or IV or other component of the sunscreen formulation. Suitable emulsifiers include conventional agents such as, for example, glycerol stearate, stearyl alcohol, cetyl alcohol, dimethicone copolyol phosphate, hexadecyl-D-glucoside,
25 octadecyl-D-glucoside, etc.

 Thickening agents may be used to increase the viscosity of the sunscreen formulations. Suitable thickening agents include carbomers, acrylate/acrylonitrile copolymers, xanthan gum and combinations of these. The carbomer thickeners include the crosslinked CARBOPOL® acrylic polymers from B.F. Goodrich. The amount of thickener
30 within the sunscreen formulation, on a solids basis without water, may range from about

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0.001 to about 5%, preferably from 0.01 to about 1% and optimally from about 0.1 to about 0.5% by weight.

Minor optional adjunct ingredients for the sunscreen formulations to be applied to skin or hair may include preservatives, waterproofing agents, fragrances, anti-foam agents, plant extracts (Aloe vera, witch hazel, cucumber, etc) opacifiers, skin conditioning agents and colorants, each in amounts effective to accomplish their respective functions.

The sunscreen formulations may optionally contain an ingredient which enhances the waterproof properties such as, compounds that form a polymeric film, such as dimethicone copolyol phosphate, diisostearoyl trimethylpropane siloxysilicate, chitosan, dimethicone, polyethylene, polyvinylpyrrolidone (PVP), polyvinylpyrrolidone/vinylacetate, PVP/Eiconsene copolymer and adipic acids/diethylene glycol/glycerine crosspolymer etc. Waterproofing agents may be present at levels of from about 0.01 to about 10% by weight.

The sunscreen formulations may also optionally contain one or more skin conditioning agents. These include humectants, exfoliants and emollients.

Humectants are polyhydric alcohols intended for moisturizing, reducing scaling and stimulating the removal of built scale from the skin. Typically polyhydric alcohols include polyalkylene glycols and more preferably alkylene polyols and their derivatives. Illustrative are propylene glycol, dipropylene glycol, polypropylene glycol, polyethylene glycol, sorbitol, 2-pyrrolidone-5-carboxylate, hydroxypropyl sorbitol, hexylene glycol, ethoxydiglycol 1,3-butylene glycol, 1,2,6-hexanetriol, glycerin, ethoxylated glycerin, propoxylated glycerin and mixtures thereof. Most preferably the humectant is glycerin. Amounts of humectant can range anywhere from 1 to 30%, preferably from 2 to 20% and optimally from about 5 to 10% by weight of the sunscreen composition.

The exfoliants suitable for use in the present may be selected from alpha-hydroxy carboxylic acids, beta hydroxycarboxylic acids and salts of these acids. Most preferred are glycolic, lactic and salicylic acids and their alkali, metal or ammonium salts.

Suitable emollients include those agents known for softening the skin or hair which may be selected from hydrocarbons, fatty acids, fatty alcohols and esters. Petrolatum is a common hydrocarbon type of emollient conditioning agent. Other hydrocarbons that may be employed include alkyl benzoate, mineral oil, polyolefins such as polydecene, and paraffins, such as isohexadecane. Fatty acids and alcohols typically have from about 10 to 30 carbon

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atoms. Illustrative are myristic, isostearic, hydroxystearic, oleic, linoleic, ricinoleic, behenic and erucic acids and alcohols. Oily ester emollients may be those selected from one or more of the following, triglyceride esters, acetoglyceride esters, ethoxylated glycerides, alkyl esters of fatty acids, ether esters, polyhydric alcohol esters and wax esters. Additional emollients or hydrophobic agents include C₁₂ to C₁₅ alkyl benzoate, dioctyladipate, octyl stearate, octyldodecanol, hexyl laurate, octyldodecyl neopentanoate, cyclomethicone, dicapryl ether, dimethicone, phenyl trimethicone, isopropyl myristate, caprylic/capric glycerides, propylene glycol dicaprylate/dicaprate and decyl oleate.

The sunscreen formulations may optionally contain one or more inorganic sunscreen agents as discussed above including micro fine surface treated titanium dioxide and micro fine untreated and surface treated zinc oxide. Titanium dioxide in the sunscreen compositions preferably has a mean primary particle size of between 5 and 150 nm and preferably from 10 to 100 nm. Titanium dioxide may have anatase, rutile or amorphous structure. The zinc oxide in the sunscreen compositions preferably has a mean primary particle size of between 5 nm and 150 nm, preferably between 10 nm and 100 nm. Examples of modified titanium dioxide compositions include:

Eusolex® T-45D (surface treated with alumina and simethicone, 45% dispersion in isononoyl isononoate);

Eusolex® T-Aqua, (surface treated with aluminum hydroxide, 25% dispersion in water); and

Eusolex® T-2000 (surface treated with alumina and simethicone), all available from MERCK KGaA.

The sunscreen formulation may also contain one or more additional monomeric organic chromophoric compounds. These can either be UV-A, UV-B or broad band filters.

Examples of suitable UV-A sunscreens include benzophenone derivatives, menthyl anthranilate, butyl methoxydibenzoyl methane and benzylidene-dioxoimidazoline derivatives.

Examples of suitable UV-B sunscreens include cinnamate derivatives, salicylate derivatives, para-aminobenzoic acid derivatives, camphor derivatives, phenylbenzimidazole derivatives and diphenylacrylate derivatives. Examples of suitable broad-band sunscreen include

benzotriazole derivatives and triazine derivatives such as anisotriazone. Others include ethylhexyltriazone and diethylhexylbutamidotriazone.

Particularly useful organic sunscreen agents that can be introduced are Avobenzene, 2-ethylhexyl p-methoxycinnamate, 4,4'-t-butylmethoxydibenzoyl methane, 2 hydroxy-4-methoxybenzophenone, octyldimethyl p-aminobenzoic acid, 2,2-dihydroxy-4-methoxybenzophenone, ethyl-4-[bis(hydroxypropyl)]aminobenzoate, 2-ethylhexyl-2-cyano-3,3-diphenylacrylate, 2-ethylhexylsalicylate, glycerol p-aminobenzoate, 3,3,5-trimethylcyclohexylsalicylate; methylanthranilate, p-dimethylaminobenzoic acid, 2-ethylhexyl p-dimethylaminobenzoate, 2-phenylbenzimidazole-5-sulfonic acid, 2-(p-dimethylamino phenyl-5-sulfoniobenzoxazoic acid and mixtures thereof.

Examples of useful commercially available organic sunscreen agents that can be introduced include 2-phenylbenzimidazole-5-sulphonic acid, 2-(4-methylbenzylidene)-camphor, 4-isopropylidibenzoyl methane all of the Eusolex™ series sold by EM Industries and Merck KGaA, Darmstadt, Germany.

Although not preferred, the sunscreen formulation may contain an additional antioxidant. Examples of suitable antioxidants which provide stability include p-hydroxybenzoic acid and its derivatives (ethylisobutyl, glyceryl esters of p-hydroxybenzoic acid); salicylates (octylamyl, phenyl, benzyl menthyl, glycerol and dipropylene glycol esters); coumarin derivatives; flavones; hydroxy or methoxy substituted benzophenones; uric or tannic acid and its derivatives; hydroquinone; and benzophenones.

In addition to providing sunscreen activity at levels which provide U.V. absorption, the compounds of Formula 1 can be introduced into a skin care formulation, a hair care formulation or other personal care formulations such as cosmetic formulations at levels which provide antioxidant activity. These compounds can be used with or without conventional antioxidants in personal care formulations such as hair care, skin care and cosmetic formulations.

The personal care formulations can be in the form of creams, ointments, suspensions, powders, oil, lotions, oleo alcoholic lotions, fatty gels, oleo-alcoholic gels and lotions, solid sticks, foams, emulsions, liquid dispersions, sprays and aerosols. More specific forms include: lipsticks, foundations, makeup, loose or press powder, eye blush, eye shadow and nail lacquer.

Sunscreen formulations of this invention as described in Formulations 1-9 can be prepared by conventional means.

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FORMULATION 1

Phase A		Phase B
Deionized water	60.0%	Ethyl-alpha-acetyl-3, methoxy-4-hydroxy cinnamate 8.75%
Disodium EDTA	.10%	Octyl salicylate 5%
Glycerin	1.5%	Aluminum stearate 5%
NaCl	3.0%	Cyclomethicone/dimethicone 10%
Butylene glycol	2.5%	Cetyl dimethicone 1%
		Cyclomethicone 2%
		ABIC- EM 97 1%
		Fragrance .15%

Procedure:

Combine phase B ingredients. Stir and heat to 70-75°C. Combine Phase A ingredients. Heat while stirring to 70-75°C. Add Phase B to Phase A while stirring. Add preservative. Stir, allowing mixture to cool to room temperature.

Formulation 2: Sunscreen Oil/Water Spray Lotion

INCI Name	Trade Name (Supplier)	% w/w
Phase A-1		
Di-isopropyl-3-methoxy-4-hydroxybenzylidene malonate		7.50
Benzophenone-3	Eusolex® 4360 (Rona)	2.50
Dicapryl ether	Cetiol® OE (Henkel)	4.50
Dimethicone	Dow Corning 200®, 50 cst (Dow)	2.00
Stearyl Alcohol	Crodacol S-70 (Croda)	0.60
PPG-2 Ceteareth-9	Eumulgin® L (Henkel)	0.40
Steareth-10	Volpo 10 (Croda)	0.50
Glyceryl stearate, PEG-100 Stearate	Arlacel® 165 (ICI)	2.80
Phase A-2		
Titanium Dioxide, Simethicone, Alumina	Eusolex® T-2000 (Rona)	5.00
Phase B-1		
Demineralized water		66.10
Chitosan, water	Hydagen® CMF (Henkel)	2.00
Glycerin USP	Emery 916 (Henkel)	2.50
Dimethicone copolyol phosphate	Pecosil PS-100 (Phoenix Chemical)	2.50
Phase B-2		
Polyquaternium 37, Mineral oil, PPG-1 trideceth-6	Salcare SC 95 (Ciba)	0.40
Phase C		
Propylene Glycol, DMDM Hydantoin, Methylparaben, Propylparaben	Paragon™ II (McIntyre)	0.70
Total		100.00

Procedure

- 5 Combine A-1; stir and heat to 60°C until all solids are dissolved. Disperse A-2 in A-1 with agitation. Combine B-1; stir and heat to 60°C. Disperse B-2 in B-1 with agitation. Add A to B while stirring vigorously. Gently homogenize allowing mixture to cool to 40°C. Add C to A/B: gently homogenize until mixture is uniform. Stir with anchor mixer allowing mixture to reach 25°C prior to packaging.
- 10 Use a high shear pump spray device for dispensing (e.g., Eurogel pump by Seaquist Perfect)

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Formulation 3: Sunscreen Cream

INCI Name	Trade Name/Manufacturer	% w/w
Phase A		
Deionized water		39.73
Carbomer (2% aq. solution)	Carbopol 980/BF Goodrich	15.00
Propylene Glycol		5.00
Methylparaben		0.20
Propylparaben		0.10
Triethanolamine (99%)		0.45
Tetrasodium EDTA		0.02
Phase B		
Octyl Methoxycinnamate	Eusolex® 2292/Rona	5.00
Benzophenone-3	Eusolex® 44360/Rona	3.00
Di-isoamyl-3-methoxy-4-hydroxybenzylidene malonate		4.50
Glyceryl Stearate (and) PEG-100 Stearate	Ariacel 165/ICI Surfactants	1.00
Cyclomethicone	Dow Corning 344 Fluid/Dow Corning	5.00
Glyceryl Stearate		4.00
Stearic Acid	Emersol 132, NF/Henkel	2.50
Isostearyl Isostearate	Prisonne ISIS 2039/Unichema	10.00
Hydrogenated Castor Oil	Castorwax/CasChem	2.00
C ₁₂₋₁₅ Alcohols Benzoate	Finsolv TN/Finetex	2.50
Total		100.00

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Procedure

Add Phase A ingredients to main vessel under impeller agitation. Heat phase A to 75-80°C. Combine Phase B ingredients; heat and mix to 85°C. Slowly add Phase B to batch; mix for 15 minutes at 85°C. Remove from heat; switch to paddle mixing and cool to room temperature.

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Formulation 4: Water/Oil Broad Spectrum Sunscreen Lotion

INCI Name	Trade Name/Manufacturer	% w/w
Phase A-1		
Octyl Methoxycinnamate	Eusolex® 2292/Rona	7.50
Iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy-cinnamate		5.00
Octyl Stearate	Cetiol 868/Henkel	2.00
Dicapryl Ether	Cetiol OE/Henkel	3.00
Cyclomethicone	Dow Corning 345 Fluid/Dow Corning	4.00
Dimethicone	DC 200 fluid 50cST/Dow Corning	2.00
PEG-30 Dipolyhydroxystearate	Ariacel P135/ICI	1.30
Laurylmethicone copolyol	Dow Corning formulation Aid 5200/Dow	2.30
Behenamidopropyl dimethylamine Behenate	Catamol 220-B/Phoenix Chemical	0.50
Phase A-2		
Titanium Dioxide (and) Alumina (and) Simethicone	Eusolex® T-2000/Rona	8.00
Deionized Water		61.00 qs
Propylene Glycol		2.00
Sodium Chloride		0.80
Phase C		
DMDM Hydantoin, Methylparaben, Propylparaben	Paragon II/McIntyre	0.60
Total		100.00

Procedure

Combine A-1; stir and heat to 55-60°C until all solids are dissolved. Disperse A-1 in A-1 by propeller agitation. Combine B; stir and heat to 50-55°C. Slowly add B to A while stirring vigorously. Add C to A/B; gently homogenize until mixture is uniform. Stir with anchor mixer allowing mixture to cool to room temperature.

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Formulation 5: UVA/UVB Sun Protection Cream with Avobenzone

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INCI Name	Trade Name/Manufacturer	% w/w
Phase A-1		
Water (demineralized)		67.80
Disodium EDTA		0.05
Propylene glycol		3.00
Methylparaben		0.15
Phase A-2		
Carbomer	Carbopol Ultrez 10/BF Goodrich	0.20
Phase B		
Isopropyl Myristate		2.00
Cetyl Alcohol, Glyceryl Stearate, PEG-75 Stearate, Ceteth 20, Steareth 20	Emulium Delta/Gattefosse	4.00
Diethyl-3-methoxy-4-hydroxybenzylidene malonate		3.50
Homomethyl salicylate	Eusolex® HMS/Rona	7.00
Octyl salicylate	Eusolex® OS/Rona	7.00
Butyl methoxydibenzoylmethane	Eusolex® 9020/Rona	3.00
Dimethicone	Dow Corning Fluid 200, 100sct/Dow	1.00
C30-38 Olefin/Isopropyl Maleate/MA Copolymer	Performa V 1608/New Phase Technologies	1.00
Phase C		
Triethanolamine (99%)		0.30
Phase D		
preservatives		q.s.
Total		100.00

Procedure

- Combine A-1; heat to 50°C while stirring until methylparaben is dissolved. Disperse A-2 in A-1 with a sifter. Heat A to 65°C. Combine B; heat to 65-70°C while stirring until solids are dissolved. Add B to A. Homogenize. Add C at 55-60°C. Continue to homogenize allowing mixture to cool to 40-45°C.

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Add D; stir with propeller mixer until uniform.
Adjust pH with TEA to 6.5-7.0

5 **Formulation 6: Oil/Water Sunscreen Lotion**

INCI Name	Trade Name/Manufacturer	% w/w
Phase A		
Diisoamyl-3-methoxy-4-hydroxybenzylidene malonate		3.00
Isopropyl Myristate	Emerest 2314/Henkel	4.00
C12-15 Alkyl Benzoate	Finsolv TN/Finetex	4.00
Cetyl Alcohol	Crodacol C-70/Croda	1.50
Steareth- 2	Bnj 72/ICI Surfactants	2.00
Steareth- 21	Bnj 721/ICI Surfactants	2.50
Dimethicone	Dow Corning Fluid 200, 100sct/Dow	0.50
Phase B		
Deionized Water		81.07
Acrylates/C10-30 Alkyl Acrylates Crosspolymer	Carbopol ETD 2020/BF Goodrich	0.20
Phase C		
Triethanolamine (99%)	TEA 99% /Union Carbide	0.23
Phase D		
Phenoxyethanol (and) isopropylparaben (and)isobutylparaben (and) butylparaben	Liquapar PE/Sutton	1.00.
Total		100.00

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Procedure

Prepare Phase B by dispersing Carbopol in water . Heat the dispersion to 70-75°C.
Combine Phase A ingredients. Stir and heat to 70-75°C.

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Add Phase B to Phase A while stirring.
Add Phase C. Homogenize until mixture cools to 45-40°C.
Add Phase D. Stir allowing mixture to cool to room temperature.

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Formulation 7: Oil/Water Sunscreen Lotion

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INCI Name	Trade Name/Manufacturer	% w/w
Phase A		
Avobenzone	Eusolex 9020/Rona	3.00
Diisoamyl-3-methoxy-4-hydroxybenzylidene malonate		3.00
Isopropyl Myristate	Emerest 2314/Henkel	4.00
C12-15 Alkyl Benzoate	Finsolv TN/Finetex	4.00
Cetyl Alcohol	Crodacol C-70/Croda	1.50
Steareth- 2	Bnj 72/ICI Surfactants	2.00
Steareth- 21	Bnj 721/ICI Surfactants	2.50
Dimethicone	Dow Corning Fluid 200, 100sct/Dow	0.50
Phase B		
Deionized Water		78.07
Acrylates/C10-30 Alkyl Acrylates Crosspolymer	Carbopol ETD 2020/BF Goodrich	0.20
Phase C		
Triethanolamine (99%)	TEA 99% /Union Carbide	0.23
Phase D		
Phenoxyethanol (and) isopropylparaben (and)isobutylparaben (and) butylparaben	Liquapar PE/Sutton	1.00
Total		100.00

Procedure

- Preapare Phase B by dispersing Carbopol in water . Heat the dispersion to 70-75°C.
- 10 Combine Phase A ingredients. Stir and heat to 70-75°C.
Add Phase B to Phase A while stirring.
Add Phase C. Homogenize until mixture cools to 45-40°C.
Add Phase D. Stir allowing mixture to cool to room temperature.

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Formulation 8: Oil/Water Sunscreen Lotion

INCI Name	Trade Name/Manufacturer	% w/w
Phase A		
Avobenzone	Eusolex 9020/Rona	3.00
Disoamyl-3-methoxy-4-hydroxy-5-isopropyl benzylidene malonate		3.00
Isopropyl Myristate	Emerest 2314/Henkel	4.00
C12-15 Alkyl Benzoate	Finsolv TN/Finetex	4.00
Cetyl Alcohol	Crodacol C-70/Croda	1.50
Steareth- 2	Bnj 72/ICI Surfactants	2.00
Steareth- 21	Bnj 721/ICI Surfactants	2.50
Dimethicone	Dow Corning Fluid 200, 100sc/Dow	0.50
Phase B		
Deionized Water		78.07
Acrylates/C10-30 Alkyl Acrylates Crosspolymer	Carbopol ETD 2020/BF Goodrich	0.20
Phase C		
Triethanolamine (99%)	TEA 99% /Union Carbide	0.23
Phase D		
Phenoxyethanol (and) isopropylparaben (and)isobutylparaben (and) butylparaben	Liquapar PE/Sutton	1.00
Total		100.00

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Procedure

- 10 Preprepare Phase B by dispersing Carbopol in water . Heat the dispersion to 70-75°C.
- Combine Phase A ingredients. Stir and heat to 70-75°C.
- Add Phase B to Phase A while stirring.
- Add Phase C. Homogenize until mixture cools to 45-40°C.
- Add Phase D. Stir allowing mixture to cool to room temperature.

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Formulation 9: Oil/Water Sunscreen Lotion

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INCI Name	Trade Name/Manufacturer	% w/w
Phase A		
Avobenzone	Eusolex 9020/Rona	3.00
Iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy-5-isopropyl cinnamate		3.00
Isopropyl Myristate	Emerest 2314/Henkel	4.00
C12-15 Alkyl Benzoate	Finsolv TN/Finetex	4.00
Cetyl Alcohol	Crodacol C-70/Croda	1.50
Steareth- 2	Bnj 72/ICI Surfactants	2.00
Steareth- 21	Bnj 721/ICI Surfactants	2.50
Dimethicone	Dow Corning Fluid 200, 100sct/Dow	0.50
Phase B		
Deionized Water		78.07
Acrylates/C10-30 Alkyl Acrylates Crosspolymer	Carbopol ETD 2020/BF Goodrich	0.20
Phase C		
Triethanolamine (99%)	TEA 99% /Union Carbide	0.23
Phase D		
Phenoxyethanol (and) isopropylparaben (and)isobutylparaben (and) butylparaben	Liquapar PE/Sutton	1.00
Total		100.00

Procedure

- Prepare Phase B by dispersing Carbopol in water . Heat the dispersion to 70-75°C.
- 10 Combine Phase A ingredients. Stir and heat to 70-75°C.
Add Phase B to Phase A while stirring.
Add Phase C. Homogenize until mixture cools to 45-40°C.
Add Phase D. Stir allowing mixture to cool to room temperature.

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Condensation of vanillin with ethyl cyanoacetate in the presence of piperidine - acetic acid and benzene as the reaction medium at reflux temperature under continuous azeotropic water removal yields the title product. The reaction takes about 1.5 hours for completion. The yield obtained is typically 95%.

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Diethyl-3-methoxy-4-hydroxy benzylidene malonate

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Condensation of 3-methoxy-4-hydroxy benzaldehyde (vanillin) with diethyl malonate in the presence of piperidine - acetic acid and benzene as the reaction medium at reflux temperature under continuous azeotropic water removal yields the title product. The reaction takes about 6.5 hours for completion.

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Example III

Ethyl-alpha-acetyl-3-methoxy-4-hydroxy-cinnamate

Condensation of 3-methoxy-4-hydroxy benzaldehyde (vanillin) with ethyl acetoacetate in the presence of piperidine - acetic acid and benzene as the reaction medium at reflux temperature yields the title product. The reaction takes about 3.5 hours for completion.

10

Example IV

Di-(2-Ethylhexyl)-3-methoxy-4-hydroxy benzylidene malonate

Transesterification of diethyl malonate using 2-ethylhexyl alcohol in neat condition at 140-155°C for 2 hours under nitrogen blanketing in the presence of sulfuric acid and after work up, followed by high vacuum distillation, yields di-6-ethylhexyl malonate.

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Condensation of 3-methoxy-4-hydroxy benzaldehyde (vanillin) with di-2-ethylhexyl malonate in the presence of piperidine - acetic acid and benzene as the reaction medium at reflux temperature under continuous azeotropic water removal yields di-2-ethylhexyl-3-methoxy-4-hydroxy benzylidene malonate. The reaction takes about nine hours for completion. The yield typically obtained is 91%.

20

Example V

Di-isoamyl-3-methoxy-4-hydroxy benzylidene malonate

Example IV is repeated, except in the condensation step, di-2-ethylhexyl malonate is replaced with di-isoamyl malonate. The yield typically obtained is over 90%.

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Example VI

Di-isopropyl-3-ethoxy-4-hydroxy benzylidene malonate

Example IV is repeated, except in the condensation step, di-2-ethylhexyl malonate is replaced with di-isopropyl malonate. The yield typically obtained is over 90%.

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Example VII

Di-dodecyl-3-methoxy-4-hydroxy benzylidene malonate

Example IV is repeated, except in the condensation step, di-2-ethylhexyl malonate is replaced
5 with di-dodecyl malonate. The yield typically obtained is over 90%.

Example VIII

Iso-propyl-alpha-acetyl-3-methoxy-4-hydroxy-cinnamate

Example III is repeated, except in the condensation step, ethyl acetoacetate is replaced with
10 iso-propyl acetoacetate. The yield of the desired product is 88%.

Example IX

Iso-butyl-alpha-acetyl-3-methoxy-4-hydroxy-cinnamate

Example III is repeated, except in the condensation step, ethylacetoacetate is replaced with
15 iso-butyl-acetoacetate. The yield of the desired product is 89%.

Example X

Iso-amyl-alpha-acetyl-3-methoxy-4-hydroxy-cinnamate

Example III is repeated, except in the condensation step, ethylacetoacetate is replaced with
20 iso-amyl acetoacetate. The yield of the desired product is 89%.

Example XI

Disoamyl-3-methoxy-4-hydroxy-5-isopropyl benzylidene malonate

Condensation of 3-methoxy-4-hydroxy-5-isopropyl benzaldehyde with di-isoamyl malonate
25 in the presence of piperidine-acetic acid and benzene as the reaction medium at reflux
temperature under continuous azeotropic water removal yields the title product. The reaction
takes about 3 hours for completion. The yield obtained is typically 90-95%.

Example XII

30 Isoamyl-alpha-acetyl-3-methoxy-4-hydroxy-5-isopropyl-cinnamate

Condensation of 3-methoxy-4-hydroxy-5-isopropyl benzaldehyde with isoamyl acetoacetate in the presence of piperidine-acetic acid and benzene as the reaction medium at reflux temperature under continuous azeotropic water removal yields the title product. The reaction takes about 4 hrs for completion. The yield obtained is typically 90-95%.

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Stabilizing Activity

Sunscreen compounds selected from the list below were evaluated for their photostability profile and photostabilization of Avobenzone following the protocol described below. Results are summarized in Table 1.

10 Compounds are illuminated in a solar simulator incorporating a 1kw Xe arc lamp, optical bench and illumination chamber. The entire output of the illumination system is focused onto the face of a 1 centimeter Cuvette (an area of 4 cm²) that contains the dilute samples of a compound of Formula I. The samples experience roughly 250 J/cm² of radiation between 290 and 400 nm over a period of two hours. The solutions contain between 0.0056
15 mg/ml and 2.5 mg/ml.

Photostability of the individual compounds is determined by differential UV-absorption spectra before and after illumination. % Loss of absorption, hence the loss of individual compound, is calculated from the reduction in optical density after illumination. Likewise,
20 stabilization of Avobenzone in the presence of individual compounds of this invention was also calculated.

Table 1: Results of Photostability & their Stabilization of Selected Compounds of this Invention

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Compound	λ_{max} , nm (Ethanol)	Photostability % Loss in 2 hrs	Stabilization of Avobenzone ² % Loss of Avobenzone in 2 hrs
Di-(2-ethylhexyl)-3-methoxy-4-hydroxy benzylidene malonate	332	1	4.5
Di-isoamyl-3-methoxy-4-hydroxy benzylidene malonate	333	3.2	3.8
Isoamyl-alpha-acetyl-3-methoxy-4-hydroxy cinnamate	339	4.1	insignificant

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Di-(2-ethylhexyl)-3-methoxy-4-hydroxy-5-isopropyl-benzylidene malonate	334	2	2.5
Isoamyl-alpha-acetyl-3-methoxy-4-hydroxy-5-isopropyl cinnamate	341	3.2	insignificant
Avobenzone	358	37	
Octocrylene (control)	303	2.8	1.5

¹Solvent used 70% ethanol/30% water; solar simulator; about 250 J/cm²

²Product/Avobenzone (1:1, w/w); %Loss of Avobenzone by HPLC

5 DPPH Test Method

A DPPH concentrate (2.5X) of 25mg of 1,1-Diphenyl-2-Picryl-Hydrazyl ACS# 1898-66-4 (Sigma #D-9132, lot 99H3601) dissolved in 250mL ethanol (USP), is prepared fresh on the measurement date. A DPPH working solution is then prepared by diluting 100mL of this concentrate to a final volume of 250mL (100 μ M/mL). A blank 13x100mm borosilicate glass screw top tube of ethanol (USP) is used to zero the spectrometer (Milton Roy, Spectronic 20+) at 517 nm and a control tube of DPPH working solution is measured under identical conditions, and taken as 0% activity. Aliquots of the 0.25% & 0.5% (RT & 45°C) test solution are added to tubes followed by the rapid addition of 4mL DPPH working solution then rapidly capped and mixed. After 20 minutes, the absorbance of each sample is read at 517 nm.

The percent reducing activity (%RA) is calculated using the following equation:

$$\% \text{ Reduction Activity} = 100 \frac{A(0) - A(20)}{A(0)}$$

Where A(0) is the absorbance value of the DPPH working solution at 517nm zeroed against an ethanol blank and A(20) is the absorbance at 517nm, 20 minutes after combining the antioxidant with the DPPH working solution.

The concentration of antioxidant (mg/ml) in the final assay mixture is calculated based on the dilution of respective aliquots of each compound in the final assay volume and %RA tabulated and plotted as percent activity at each concentration in the dilution series.

Antioxidant Property

The antioxidant activity of selected compounds of this invention was determined from their reducing activity of a DPPH radical. Results of selected compounds from this invention are summarized in Table 2.

Table 2: Antioxidant Activity of Selected Compounds of this Invention

Compounds	%Reducing Activity of DPPH Radical at 30 µg/ml	µg/ml Needed to Reduce 50% of DPPH radical (Ec ₅₀)
Di-(2-ethylhexyl)-3-methoxy-4-hydroxy benzylidene malonate	7.4	188
Di-isoamyl-3-methoxy-4-hydroxy benzylidene malonate	9.5	172
Isoamyl-α-acetyl-3-methoxy-4-hydroxy cinnamate	22	72
Di-(2-ethylhexyl)-3-methoxy-4-hydroxy-5-isopropyl-benzylidene malonate	11.2	161
Isoamyl-α-acetyl-3-methoxy-4-hydroxy-5-isopropyl cinnamate	28	68
Tinogard		46

In order to boost antioxidant activity of the compounds of the present invention, other antioxidants can be combined. Some examples are those antioxidants mentioned above and Tocopherols, tocopherylacetate, Ascorbic acid, Emblica antioxidants, Proanthocyanidins (from pine bark, grape seed extract, and the like) green tea polyphenols, rosemary antioxidants, gallic acid, ellagic acid, butylhydroxy toluene (BHT), butylhydroxy anisole (BHA) and the like.

Photostability

The photostability of selected compounds (see Table 1) was tested according to the procedures below.

A solar simulator used for illumination of the samples in the experiments is constructed incorporating a 1kw Xe arc lamp, optical bench and sample illumination chamber. The lamp output is filtered through a water filter with a course window to remove most of the infrared radiation and optical filters to remove wavelengths below 290 nm. The output of the illumination system is focused onto the face of a 1 cm quartz Cuvette that is thermally equilibrated with a constant temperature water bath at 25°C. A magnetic stir is

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mounted under the Cuvette so that the samples could be stirred while being illuminated. An electric shutter is controlled by a dark room timer to provide precise control of illumination times. The solar simulator is constructed to provide illumination that closely matches terrestrial sunlight. The solar simulator delivers roughly 250 J/cm² over a 2-hour period of illumination in a 290-490 nm range. This irradiance is determined using two nitrobenzaldehyde chemical actinometry. The irradiance is much higher than other solar simulator systems which typically illuminate a large area in order to illuminate many samples simultaneously rather than being focused down to a very small area.

Each sunscreen compound is dissolved in 70% ethanol/30% water and the UV visible absorption spectrum measured with a Shimadzu UV 2101-double beam spectrophotometer using the solvent as reference. A control solution of Octocrylene is prepared and the UV-visible absorption spectrum measured. Each solution is then illuminated for two hours in the solar simulator. After illumination, the absorption spectrum is again measured for each solution.

As Table 1 illustrates, the tested compounds were found to be photostable after two hours of illumination in a Xe-arc solar simulator. This data shows compounds of this invention have comparable photostabilities to Octocrylene under the experimental conditions employed.

The UV-spectral study of the present inventive compounds shows that they have broad absorption bands that extend across the UV region. They exhibit lower molar absorption than Avobenzone but have much better photostability than Avobenzone (see Table 1).

Stabilizing Activity

The stabilizing activity of selected compounds (see Table 1) toward Avobenzone was tested and compared with a conventional product according to the procedures below.

Individual solutions of selected sunscreen compounds (see Table 1) with Avobenzone were as follows. Each sunscreen compound was dissolved in 50% ethanol/50% H₂O solution containing roughly an equal molar amount of Avobenzone. A similar solution containing Di-2-ethylhexyl-2,6-naphthalene dicarboxylic acid (DENDA) and Avobenzone was also prepared. Each solution was then illuminated in the solar simulator as configured above for the

photostability tests and aliquots of each solution were removed at 30-minute time intervals. These aliquots were injected into an HPLC and the loss of Avobenzone was followed with illumination time. The high performance liquid chromatograph (HPLC) used for all experiments reported therein incorporated a Spectra-Physics model P-200 pump with an Applied Biosystems model 785A UV-Visible detector with a Rheodyne manual injector incorporating a 50 ml sample loop and a 150 x 4.6 mm reversed-phase C₁₈ column (Alltech). All analyses were carried out under isocratic elution conditions using CH₃OH/H₂O mixtures for the mobile phase at a flow rate of 1 H₂O ml per minute. It was necessary to employ HPLC separation of Avobenzone from each of the sunscreen compounds to quantify Avobenzone due to the absorption spectra overlap with some of these compounds.

The loss of Avobenzone when illuminated alone in solution rapidly exhibited a loss of 37% in 2 hours in the solar simulator (Table 1).

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the examples. From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.